

MINERAL PRECIPITATION IN AN UNSATURATED TUFF FRACTURE – PERMEABILITY EFFECTS

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RESEARCH OBJECTIVES

Upon the emplacement of heat-generating nuclear waste in the potential nuclear waste repository at Yucca Mountain, Nevada, water naturally present in the rock will begin to boil and will be transported in the open fractures. When this water vapor reaches cooler rock, it will condense and may begin to flow. This condensate will not be in chemical equilibrium with the surrounding rock; therefore it will begin to dissolve a portion of the rock it contacts. If it flows towards the hot nuclear waste and boils again, it will deposit the dissolved constituents in the fracture, reducing the fracture permeability. Upon boiling, the cycle will begin again. The objective of this research is to experimentally investigate tuff dissolution and mineral precipitation under similar conditions.

APPROACH

An experiment was designed guided by numerical simulations. Water was equilibrated with carbon dioxide at levels comparable to those measured near the Drift-Scale Test, a large heated experiment at Yucca Mountain. It was then run through crushed tuff maintained at 95°C to simulate condensation and mineral dissolution. Water samples were analyzed to provide a data set for tuff dissolution at near-boiling temperatures. The water was then introduced into a book-sized tuff fracture made from two flat tuff slabs separated by about 20 microns which was heated to 130°C at the bottom. The permeability of the fracture was monitored for changes. The narrow fracture sealed in about 10 days. After the fracture clogged, it was opened and inspected to determine the physical and mineralogical structure of the precipitated solids.

ACCOMPLISHMENTS

The experiment has been completed and data analysis is ongoing. The primary constituents in the water leaving the crushed tuff were silica, sodium, carbonate and potassium. The pH, initially acidic due to dissolved carbon dioxide, ranged from 9.2 to 8.2. Solids precipitated in the fracture at temperatures from below boiling to 130°C. Only a few small regions of precipitate were observed in the below-boiling region. In the region near 100°C, mineral precipitation occurred nonuniformly in narrow bands which span the aperture and block flow (Figure 1), and in a glaze over part of the fracture wall. In regions near 130°C, the precipitate formed very porous honeycomb structures. The mineralogy of the precipitate with respect to the fracture location is currently being evaluated.

SIGNIFICANCE OF FINDINGS

Mineral precipitation in fractures is important for both nuclear waste disposal and geothermal reservoir engineering. Experiments have been performed in water-saturated systems, and many numerical studies have pre-

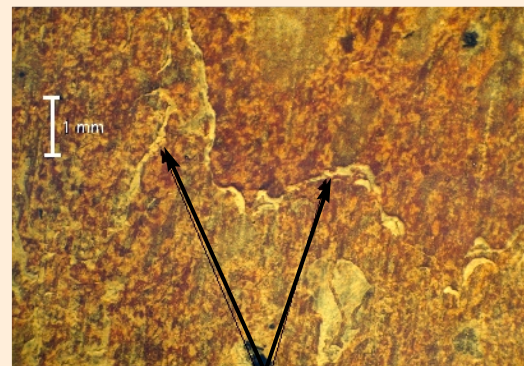


Figure 1. White precipitate bands in the near-boiling region.

dicted the effects of precipitation. This study provides an understanding of the processes of tuff dissolution in a water-saturated environment, and mineral precipitation in an unsaturated fracture. This study also provides insight towards the physical structure of the precipitate in relation to the structure of the fracture, which is crucial to understanding the effects on permeability and flow in the fracture.

RELATED PUBLICATIONS

Kneafsey, T.J., and K. Pruess, Laboratory experiments on heat-driven two-phase flows in natural and artificial rock fractures, *Water Resources Research*, 34, pp. 3349 - 3367, 1998.

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